

ILRS Analysis Standing Committee pilot project on the determination of systematic errors in ILRS observations. First assessment of inter-AC consistency.

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This short note contains a summary, in graphical format, of the level of consistency found between the results of the ILRS Analysis Centres that have to date contributed their solutions to the Analysis Standing Committee pilot project on systematic errors determination. The context, rationale, and agreed proposal delineating the analysis strategy to be followed for this pilot project is available from the ILRS website:

http://ilrs.gsfc.nasa.gov/docs/2016/Proposed_ILRS_AWG_Bias_PP_2015_16.pdf

Briefly, contributing ACs were requested to compute orbital solutions for the period 2005–2008, using SLR observations to the LAGEOS satellites to estimate weekly station coordinates and daily EOPs in addition to weekly range biases for *all* tracking stations at *all* epochs. It was recommended that the known systematic errors tabulated in the ASC data handling file were not to be applied; this was observed by all ACs that submitted their solutions. Two different series were requested for this pilot project, identical in all respects except for the following:

- RB L1/L2 solution: range bias parameters estimated separately for LAGEOS and LAGEOS-2
- RB LC solution: combined range bias estimated from both LAGEOS satellites

There should be no further differences between the computation of these series and those produced for the ITRF2014 reanalysis effort, although the SINEX headers indicate that for this exercise two ACs have in fact switched to ITRF2014 for their a priori station coordinates (ASI, NSGF). Additionally, the DGFI AC appears to have used the geopotential model EIGEN-6S2, while all the others employed GGM05S. The differences in a priori coordinates are not expected to influence the results of *this* pilot project in any practical way, and the use of alternative geopotential models can be argued to be a strength rather than a disadvantage.

As of May 2016, five out of eight Analysis Centres completed and submitted their results. Both solution series were produced by ASI, DGFI, JCET and NSGF, while GFZ submitted the separate range bias solution (RB L1/L2) alone.

Comparison

One of the primary aims of this pilot project is to establish whether different ACs are able to identify systematic errors in the LAGEOS data (and their treatment),

as well as the degree of consistency between their results. As the weekly solutions are inevitably noisy, and the focus here is on the potential presence and detection of long-term systematic errors, the comparison must be performed on a sufficiently long time scale to capture the underlying biases.

For the purposes of this comparison we computed and plotted the averages of the weekly-estimated range biases for the whole period under consideration, 2005–2008 (figure 1). This would be too coarse a method to ascertain the time variation of the estimated systematic errors for an individual station, where six or twelve-month averages would be more informative. However, with the stated above objective of assessing the consistency between the different pilot project results, long-term averaging provides a simple, single figure of merit (per station) with great statistical significance.

Furthermore, if systematic errors are found even after averaging four years of data, these are sure to affect the station heights of the sites involved and eventually find their way onto the reference frame. In order to illustrate this point (of uttermost importance) we also computed the scale factors relative to ITRF2014 of the two series provided for this pilot project, as well as for the standard solutions produced for the ILRS submission to ITRF2014. This is shown in figure 2.

Finally, in order to assess whether real, measurable, significant differences between the laser ranging observations to LAGEOS and LAGEOS-2 can be recovered, we computed the difference between the 4-years averages of the per-station range bias estimates (figure 3). Note that although this kind of analysis suggests that the case for estimating separate range bias parameters per satellite is insufficiently motivated, other considerations might well justify it (e.g. at ASC meeting in Vienna 2016 it was indicated by ASI that EOPs may benefit from separate RB estimation).

Data treatment. The results presented in this document are straightforward. The only data manipulation step prior to computing the various averaged quantities displayed here was the removal of outliers from each data series (per station, per AC, over the whole period), which at any rate did not alter the results in any significant way.

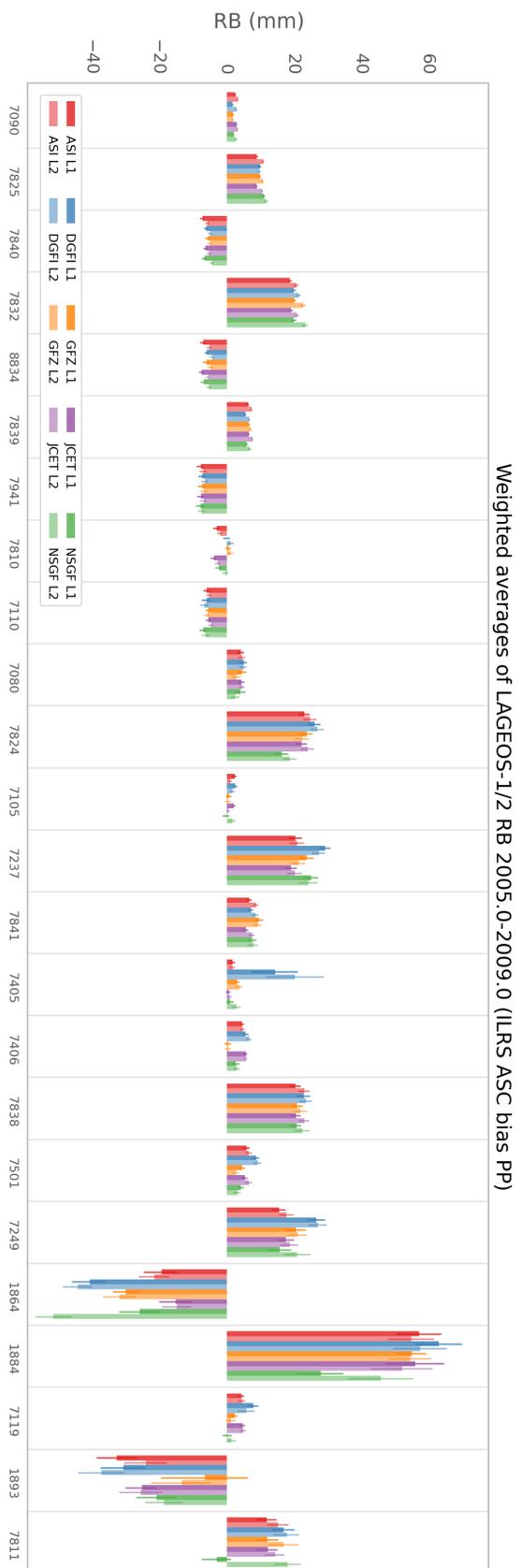
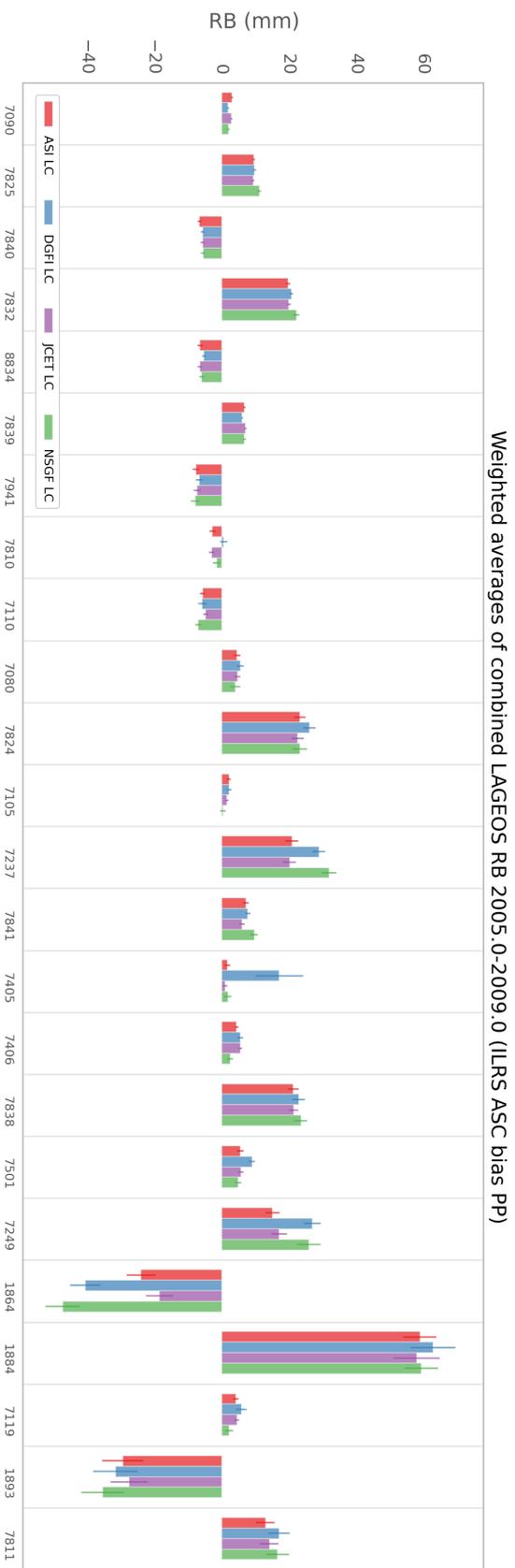


Figure 1 – Weighted averages, per Analysis Centre, of weekly estimated range biases for the 24 most prolific stations during the 2005.0–2009.0 period. Top: ASC bias pilot project solutions with combined LAGEOS-1/2 range bias estimation. Bottom: ASC bias pilot project solutions with separate range bias estimation for LAGEOS and LAGEOS-2. Bias entries from the data handling file not applied. Error bars represent the standard error of the weighted means.

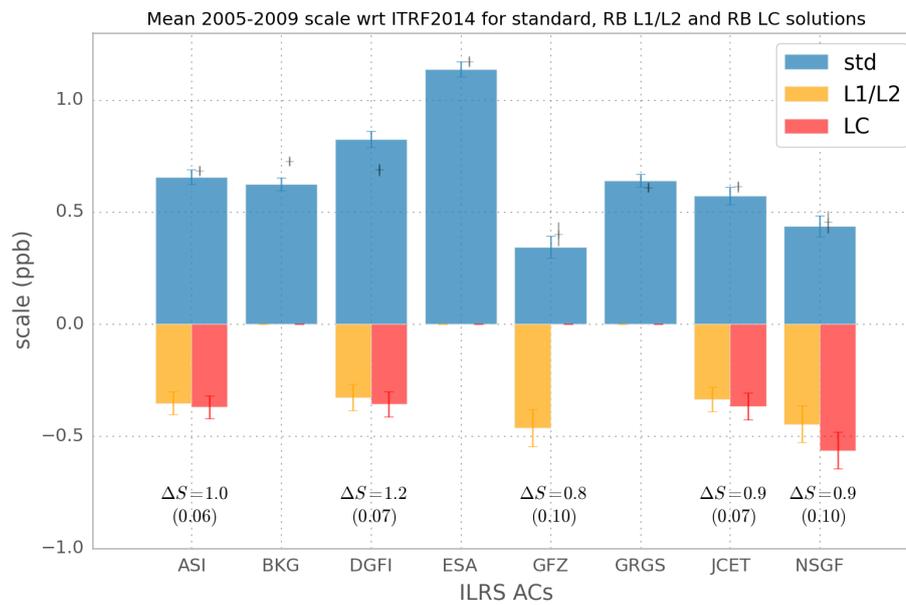


Figure 2 – Average of 2005.0–2009.0 weekly estimated scale factors of individual ILRS AC solutions relative to ITRF2014. Blue: standard solutions from each AC submission to ITRF2014. Yellow: ASC bias pilot project solutions with separate range bias estimation for LAGEOS and LAGEOS-2. Red: ASC bias pilot project solutions with combined LAGEOS-1/2 range bias estimation. The total average scale changes between the standard and the separate range bias solutions, when available, are noted in the figure. The grey crosses indicate the average and standard errors, for the same period, of the scale factors computed by the ASI Combination Centre for the ILRS submission to ITRF2014, relative to SLRF2008.

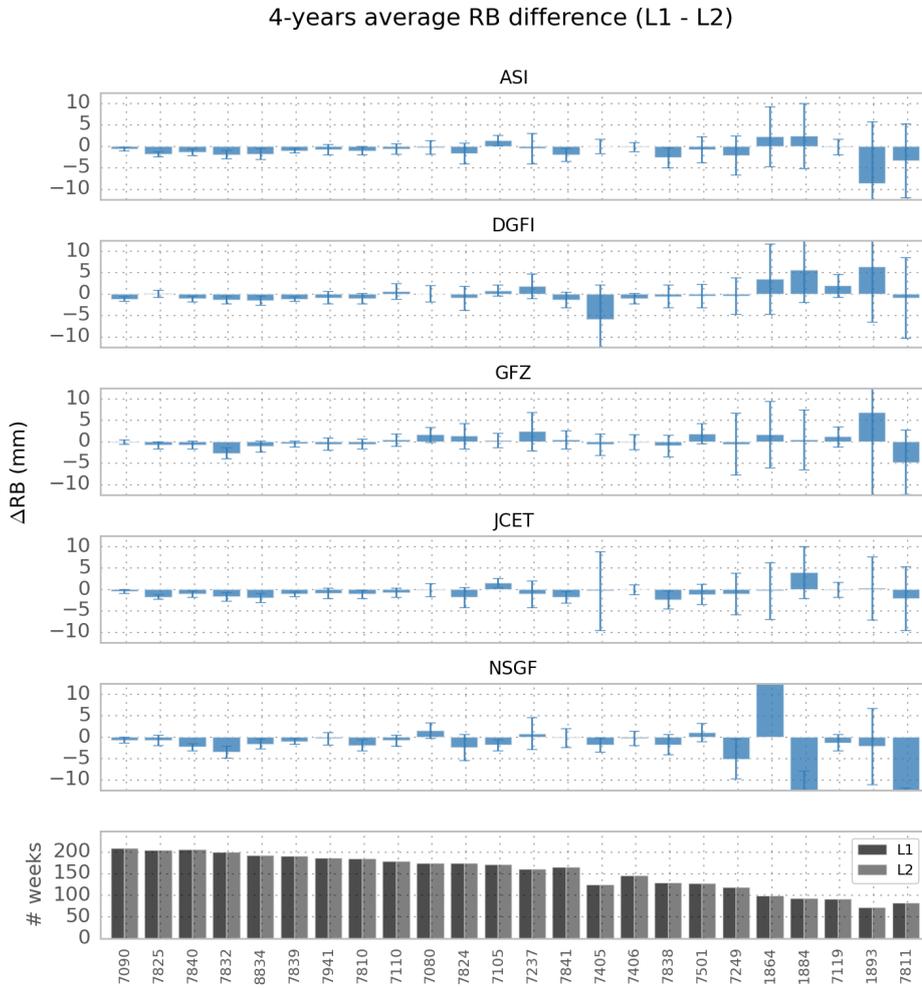


Figure 3 – Difference between LAGEOS and LAGEOS-2 averaged range biases over the 2005–2009 period, per AC and station. The bars represent the standard errors of the difference between means. The bottom plot shows the average number of available weekly solutions, over the five contributing ACs, during this 4-years period per satellite and station.